Measuring centrality in d-Au with the PHENIX Forward Calorimeter detectors (FCAL)

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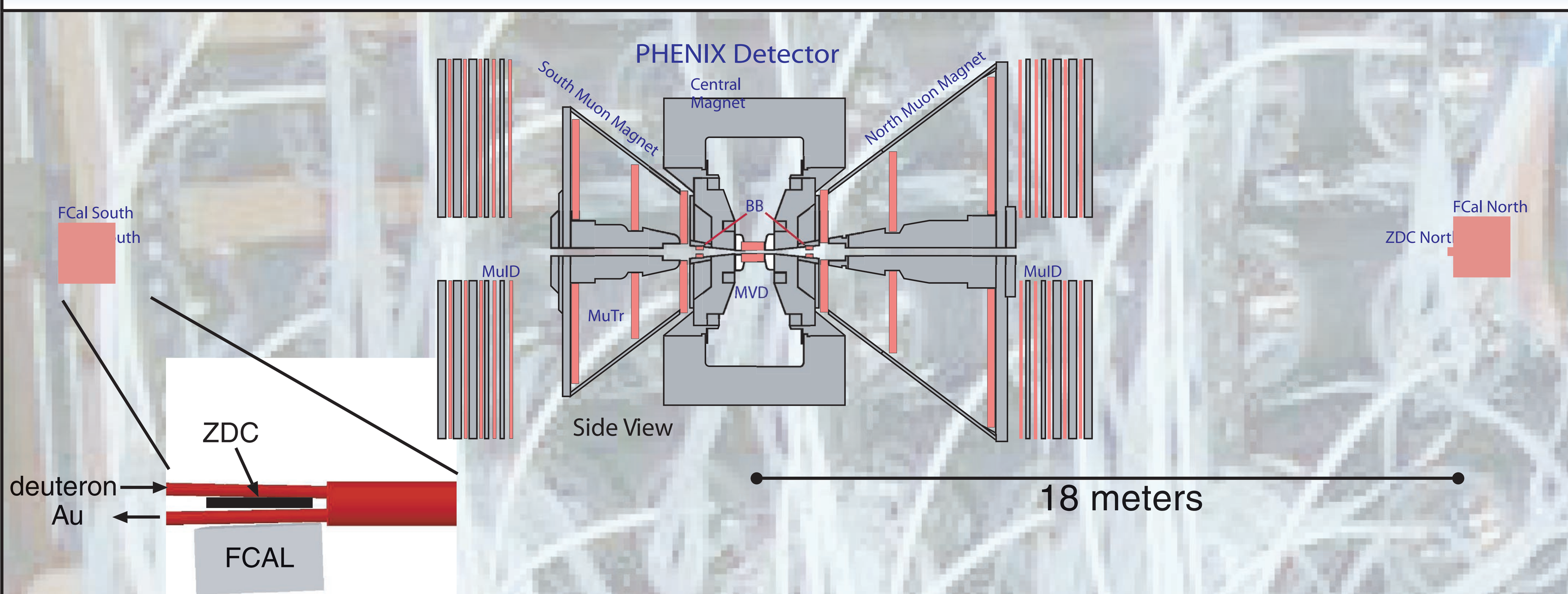
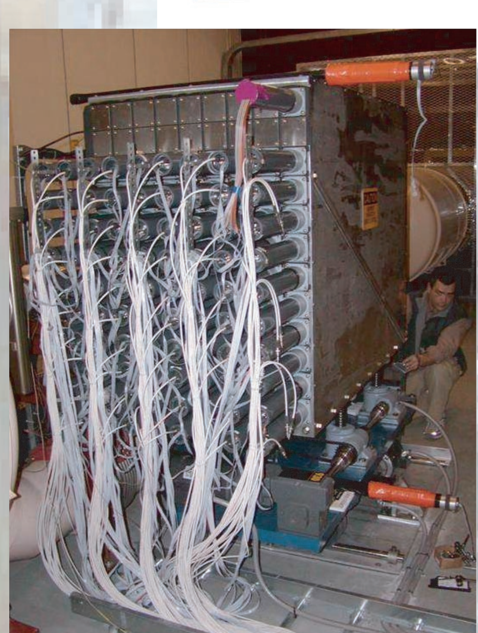
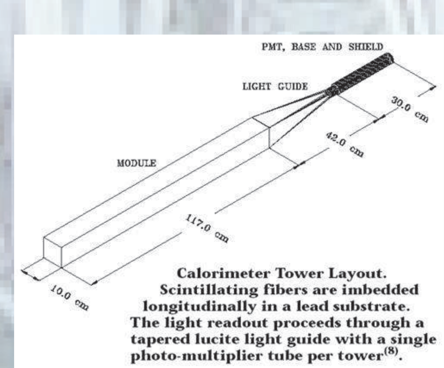
Abstract

In the 2003 d-Au Run PHENIX installed a pair Forward Calorimeters (FCAL) in the RHIC tunnels to measure the forward protons on both sides of the interaction region. Each calorimeter is a 9x10 array of lead scintillator modules, 10x10cm x 5.9 interaction lengths, used previously in the AGS E864 experiment. The calorimeters have been placed adjacent to the outgoing beam pipes for d and Au, 18m from the interaction point. The primary motivation for them is to improve the centrality measurement in d-Au collisions by measuring the energy from "grey/recoil" and "black/evaporation" protons of the interacted Au nucleus. Centrality measurements from the FCAL detectors will be presented and compared to similar measurements from other detectors.

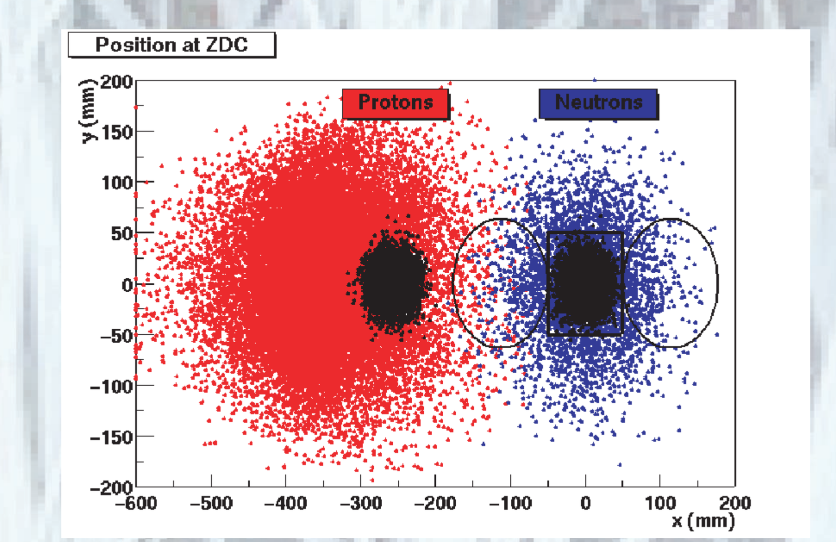
Experiment







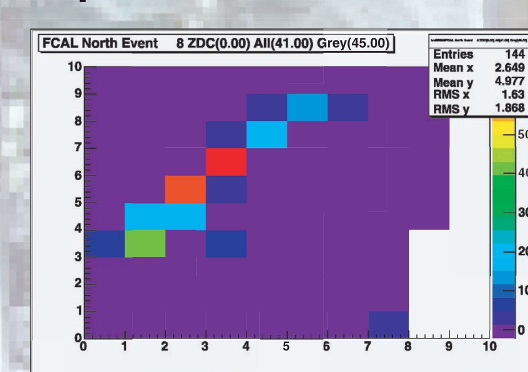
Each Forward Calorimeter is a 9x10 array of towers positioned downstream of the RHIC DX magnets alongside the Zero Degree Calorimeters. These towers were formerly used in the AGS E864.



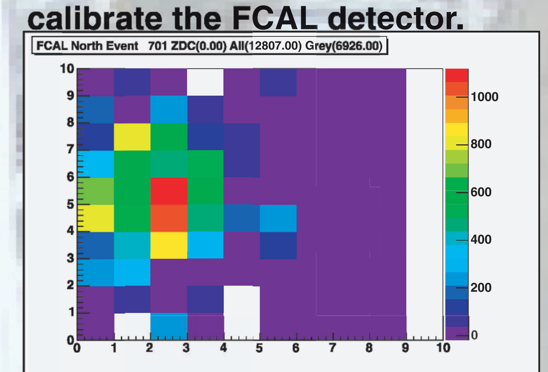
The location of recoil (blue and red) and evaporation (black) protons and neutrons is shown at the ZDC z-location.

RHIC d-Au Data

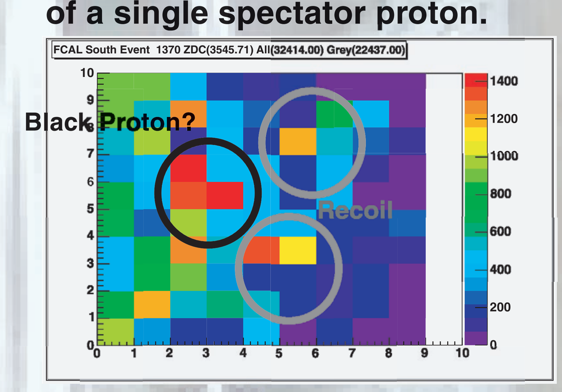
Two forward calorimeters were installed downstream of the PHENIX detector prior to a RHIC run colliding deuteron and Au nuclei. The South calorimeter was positioned to detect recoil and evaporation protons from the Au nucleus. The North colorimeter was positioned to detect the spectator proton from the deuteron.



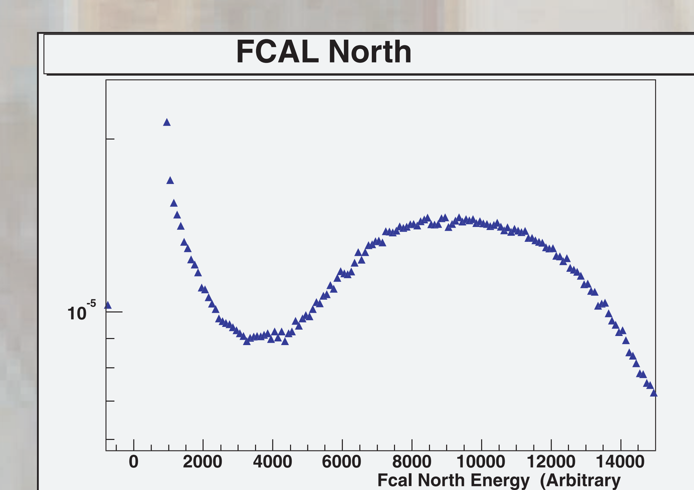
Cosmic events were used to calibrate the FCAL detector.



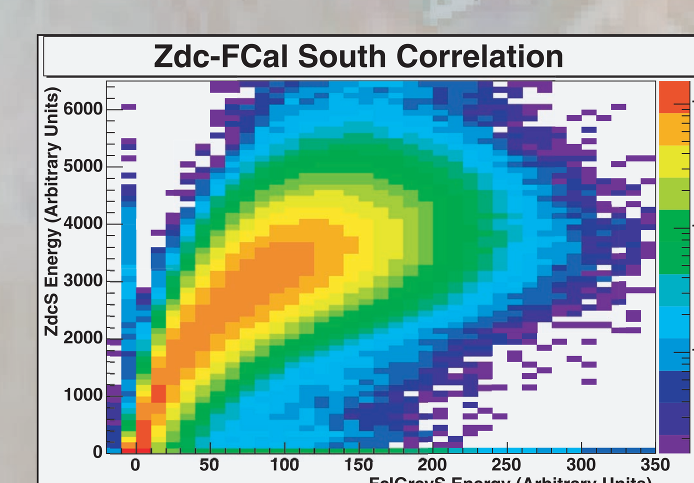
The North FCAL detects the energy of a single spectator proton.



The South FCAL detects the energy evaporation protons, recoil nucleons, and forward hadrons from a single event.



In a deuteron-Au collision, either the deuteron proton or the deuteron neutron or both can interact with the Au nucleus. When only the neutron interacts, the spectator proton is swept by the beam magnet into the North FCAL.



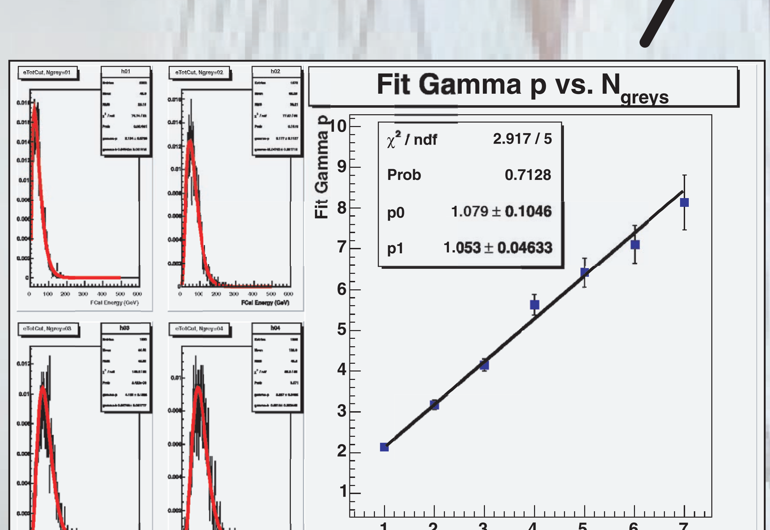
The Au side shows a strong correlation between the ZDC which measures evaporation neutrons and the FCAL which measures both recoil and evaporation protons. In more central collisions, the evaporation necleons saturate but the energy from recoil protons measured in the FCAL continues to increase.

RQMD Simulation

Previous experiments have demonstrated the use of recoil nucleons to determine the centrality of a collision usually characterized by the number of binary nucleon-nucleon collisions. The goal of this analysis is to extract the number of binary collisions from the energy deposited by the recoil protons in the Forward Calorimeter. A model is evaluated on a RQMD simulation of d-Au collisions.

* I. Chemalkin, *et al.* (E910) Phys. Rev. C60 (1999)

$$P(E_{FCAL}) = \sum_{\nu} [P_{Glauber}(\nu) \sum_{N_{grey\,Acc}} P(E_{FCAL};N_{grey\,Acc}) \sum_{N_{grey}} P(N_{grey\,Acc};N_{grey}) \quad P(N_{grey};\nu)]$$



A GEANT simulation provides the simulated detector response given a number of recoil protons from the RQMD simulated collisions: $P(E_{FCal};Ngrey)$ is Gamma Distribution with $<E_{FCal}>$=a0 + a1*Ngrey

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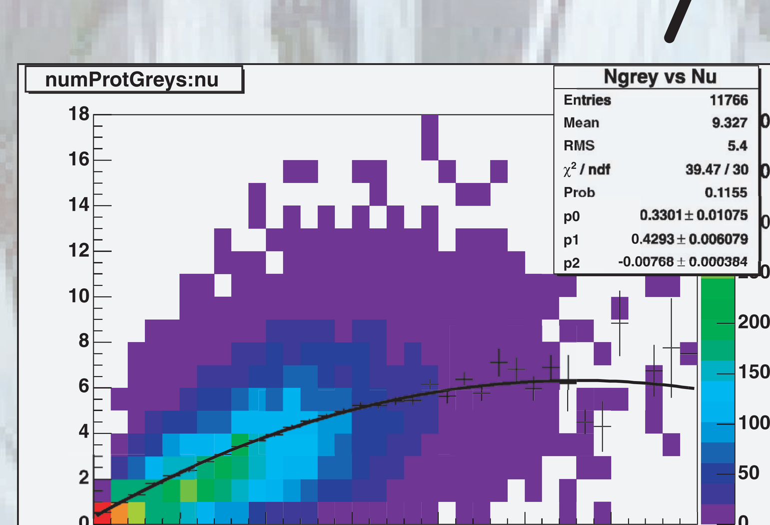
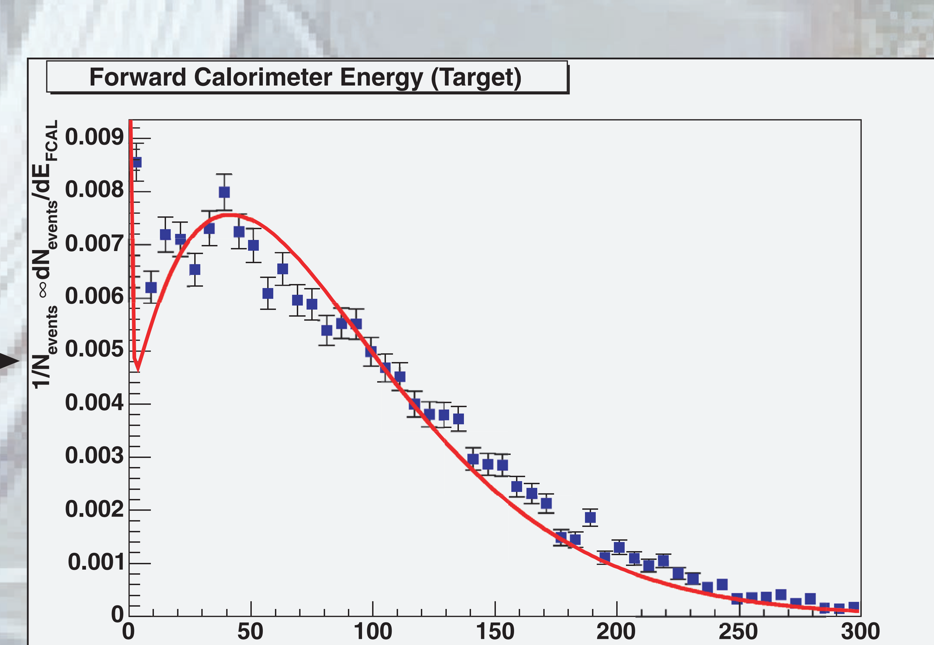


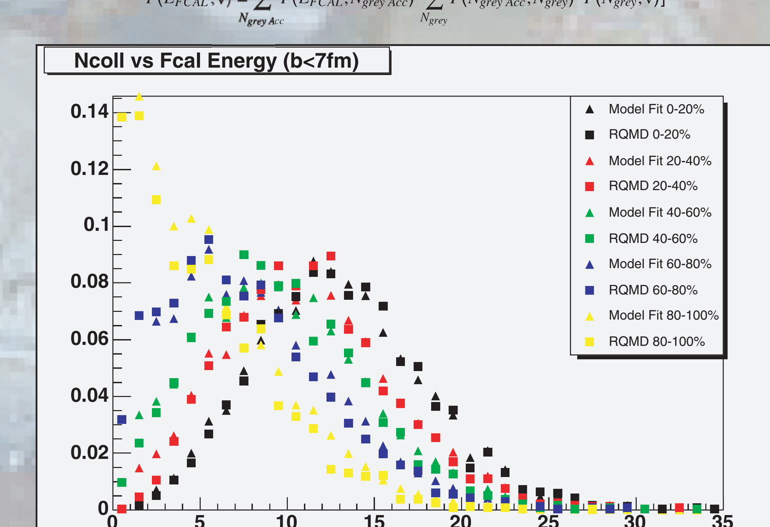
The RQMD event generator provides a realistic correlation for the number of recoil protons for a given number of projectile - target nulceon scatterings: P(Ngrey;nu) is binomial distribution with <Ngrey>=c0 + c1x ν + c2 x ν^2



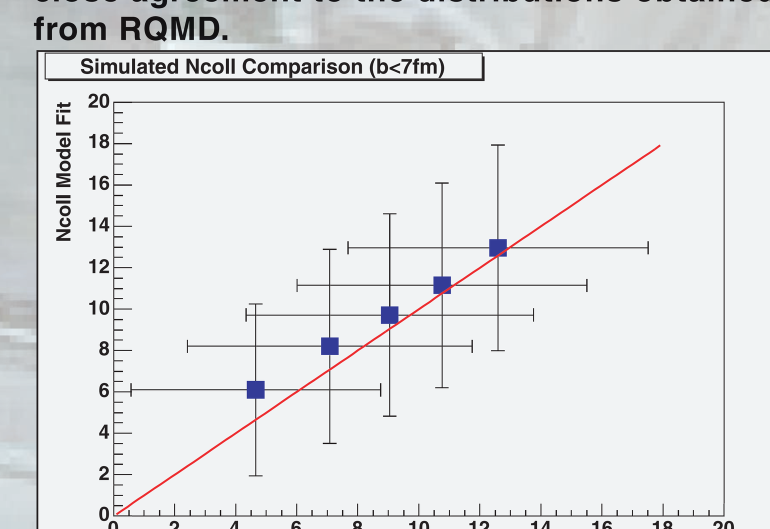
This model reproduces well the total energy distribution of the Forward Calorimeter in d-Au collisions simulated with RQMD.

The number of binary collisions may be extracted from the following distribution:

$$P(E_{FCAL};\nu) = \sum_{N_{grey\,Acc}} P(E_{FCAL};N_{grey\,Acc}) \sum_{N_{grey}} P(N_{grey\,Acc};N_{grey}) \; P(N_{grey};\nu)]$$



The binary collision distribution for five FCAL energy bins is extracted using the model. The distributions obtained from the model show close agreement to the distributions obtained from RQMD.



The mean and RMS of the binary collision distributions are extracted from the model and compared to the RQMD simulation. The mean values obtained from the model show close agreement with RQMD.

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